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AN ASSESSMENT OF PESTICIDE RESEARCH PROJECTS

Funded by the Ministry of the Environment through the Ontario Pesticides Advisory Committee

1983-1984

Ontario

The Ontario Pesticides Advisory Committee

Hon. Andrew S. Brandt
Minister

Dr. Allan E. Dyer
Deputy Minister

Date Due

AN ASSESSMENT OF

PESTICIDE RESEARCH PROJECTS

FUNDED BY

THE MINISTRY OF THE ENVIRONMENT

THROUGH

THE ONTARIO PESTICIDES ADVISORY COMMITTEE

1983 - 1984

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RESEARCH PROJECTS FUNDED THROUGH
THE ONTARIO PESTICIDES ADVISORY COMMITTEE
1983 - 1984

I. SUMMARY

1) In 1983-84, the Ontario Pesticides Advisory Committee continued a program, begun in 1973, of funding research on pesticides. The objectives of the program are:

   (a) To find alternative pesticides for those deemed environmentally hazardous and thus restricted in use.

   (b) To determine potential environmental hazards with pesticides currently in use.

   (c) To reduce pesticide input into the environment.

2) Fourty-seven research proposals totalling $644,649 were received.

3) Twenty-five proposals were funded with a total value of $300,300. Awards averaged $12,012 and ranged from $4,700 to $30,000.

4) Four grants totalling $42,500 were awarded for studies on development of alternative pesticides.

5) Ten grants totalling $132,000 were allocated to studies on the behaviour and fate of pesticides in the environment and on potential environmental hazards to non-target organisms.

6) Eleven grants totalling $125,800 were allocated for studies aimed at reducing pesticide input into the environment, while still achieving effective pest control.

7) The Pesticides Advisory Committee is pleased with the research progress made in 1983-84. The Committee recognizes that with the limited funds available the program can be expected to act only as a catalyst in stimulating support by other agencies for research on pesticides; support which is greatly appreciated.

II. RECOMMENDATIONS

The Pesticides Advisory Committee recommends that:

1) The Ministry of the Environment continue to support research programs directed toward development of pest control programs which will not pose any serious environmental hazard.

2) The Pesticides Advisory Committee continue to supervise the program following guidelines which have been developed.

III. REVIEW OF THE RESEARCH PROGRAM

The Ministry of the Environment first allocated funds to the Ontario Pesticides Advisory Committee to sponsor pesticide-related research in 1973. Results have been summarized in Annual Reports from 1974-1984, inclusive, which are available from OPAC on request. Results obtained have encouraged the committee to recommend that the research program be continued under its supervision and the committee is gratified that this recommendation has been accepted. The OPAC research budget in 1983-84 was $300,000.

Terms of Reference developed by OPAC to govern the awarding of research grants are based on three objectives, *i.e.*, the need to find suitable replacements for pesticides deemed hazardous and restricted for use in Ontario; the need to determine if pesticides in use pose any serious environmental hazard; and the need to develop more effective approaches to pest control leading to a reduction of pesticide input into the environment. The "Application for Research Support" (APPENDIX I) invited proposals in five general areas relating to these three objectives. Invitations for applications for research support were widely distributed in January, 1983 to personnel in Ontario universities, industry and government (copies of the mailing list are available on request), with the deadline for applications being February 28, 1983.

Forty-seven research proposals totalling $644, 649 were received. Most (39) were from universities/colleges (Brock, Guelph, Queens, Sault College of Applied Arts and Technology, Toronto, Waterloo, and Western). The remaining applications were submitted by industry or other organizations. (A list of titles of research proposals submitted for consideration by OPAC is available on request.) Applications were considered first by the research sub-committee (G.S. Cooper, P.D. Foley, R. Frank, J.C. Ingratta, B.H. McGauley, J.J. Onderdonk, G.R. Stephenson, I. Wile, and C.R. Harris (Chairman), and then by the Advisory Committee. Twenty-five proposals were accepted, valued at $300,300. Awards averaged $12,012 (range $4,700 to $30,000). Most of the grants were awarded to individuals at universities. Disbursement of research funds by organization is summarized below:

Organization	Number of Research Grants Awarded	$ Total Research Funds
University of Guelph	13	170,700
University of Western Ontario	5	61,900
University of Toronto	2	18,200
Sault College of Applied Technology	1	12,000
Other	4	37,500
TOTAL	25	300,300

Direction and progress of the research program were monitored by the Advisory Committee in several ways. Initially, some applicants were asked to modify their proposals to better meet the research guidelines. Informal contacts between the research sub-committee and some grant recipients were established. In June 1983, as part of the annual OPAC field trip, visits to some of the researchers receiving support were included in the agenda, thus giving OPAC members an opportunity to become acquainted with cooperating scientists and research in progress. In January 1984, OPAC sponsored a two-day research seminar at which recipients of grants discussed their research results. This meeting was attended by Advisory Committee members and more than 80 people interested in pesticide-related research. Each recipient of a grant was asked to provide OPAC with a summary of results (APPENDIX III). Published research reports relating to research sponsored by the Committee are listed in APPENDIX IV.

Progress made in 1983-84 relative to the objectives of the research program may be summarized as follows:

OBJECTIVE 1: *To find alternative pesticides for those deemed environmentally hazardous and thus restricted in use.*

Four grants were awarded under this objective, totalling $42,500.

A study initiated in the fall of 1981 to develop an effective, economical approach to suppressing meadow mice in apple orchards was continued. Results over two years indicate that poison bait stations located at intervals throughout an orchard offer better mouse control than the currently recommended fall broadcast application of zinc phosphide bait (19)*.

Further research was supported on two herbicide-related projects. In one study aimed at identifying alternatives to use of allidochlor for weed control in onions, several materials showed promise as pre- and post-emergence herbicides (13). In another study designed to evaluate the potential of triclopyr as a brush control agent, efficacy data indicated that it was more efficient than 2,4-D/2,4-DP in suppressing white ash and sugar maple, while most grasses were resistant to it. Triclopyr was intermediate in soil persistence between 2,4,5-T and picloram. It was more mobile in soil than 2,4-D but less mobile than picloram (20).

The carpenter ant, an important structural pest in Ontario, is usually controlled using chlordane. A study was begun to determine if insecticidal baits would have potential for carpenter ant control. Fusel oil showed the best potential of several materials tested as attractants. Insecticides tested proved repellent to the ants when formulated into attractant-containing baits (1).

* *Numbers in brackets refer to Abstracts included in APPENDIX III.*

OBJECTIVE 2: *To determine potential environmental hazards with pesticides presently in use.*

This objective promoted 10 grants totalling $132,000.

The shortage of effective pesticides for insect and disease control presents serious problems for producers of many fruits and vegetables. As registration of pesticides for use on such "minor" crops is often hampered by lack of residue data, several studies were supported in 1983. In addition, captan residues occurring on greenhouse and field tomatoes and on strawberries were determined. The extent to which residues were transferred to workers picking captan-treated strawberries also was investigated (14). Spray coverage, biological effectiveness and residue levels of captan on strawberries resulting from current control recommendations were studied. Spray coverage achieved with the various sprayers tested were less than adequate; irrigation application was unsatisfactory. None of the berries received sufficient spray deposit to avoid the risk of disease infection. Captan residues on berries varied widely but generally exceeded the newly-established 5 ppm legal limit (9). A study relating to captan toxicology was funded late in 1983, results of which will be available in 1985 (8).

Research on dislodgeable pesticide residues in turfgrass was continued. Dislodgeable residues of granular and liquid formulations of 2,4-D amine, Killex®, diazinon, chlorpyrifos, and isofenphos were generally low immediately after treatment and negligible after two to three days. Dislodgeable residues from granular applications were significantly lower than those resulting from liquid formulations, particularly on the day of application (18).

In conjunction with other work being supported on pest management in corn (7), a study was initiated to determine the relative persistence in soil of insecticides recommended or being evaluated for corn rootworm control. Most of the 10 insecticides studied were sufficiently persistent to provide rootworm control and nearly all declined to <3% of the initial application by fall. Data were obtained in laboratory and field studies which demonstrated that soil microbial populations can develop the ability to rapidly degrade methylcarbamate insecticides such as carbofuran - a phenomenon which could have important crop protection and environmental implications (4). A similar soil behaviour study on the herbicide, butylate$^+$ was supported. Results indicated that herbicide activity was dependent on soil type and that soil microbes are involved in butylate$^+$ degradation in soil (5).

A three-year study to assess the influence of environmental conditions on the rate of degradation of insecticides in soil was completed. Soil temperature, moisture, and pH all influenced chemical and/or biochemical degradation rates (15).

Concern over the possible contamination of groundwater by residues of water-soluble pesticides has resulted in OPAC support for environmental studies on several such pesticides. An earlier laboratory study on the effect of sequential periods of simulated rainfall and drying on metalaxyl movement in soil indicated that this relatively water soluble fungicide moved downward

with each rainfall but then moved upward with each drying cycle. Results of a field study done to determine if this phenomenon occurs under natural conditions were inconclusive (6). The systemic insecticide, disulfoton, was subjected to intensive study. Disulfoton was metabolized, in part, to the more water soluble sulfoxide and sulfone in soil; disulfoton residues were more persistent in dry than in moist soil; laboratory studies indicated that disulfoton residues might have the potential to leach through soil; residues in potatoes harvested from disulfoton-treated soils were negligible (3).

Laboratory and field studies were done to determine if residues of the pyrethroid insecticide, fenvalerate, influenced the filter feeding behaviour of zooplankton. In laboratory tests, feeding activity of several zooplankton species was affected at fenvalerate concentrations in water as low as 0.05 μgL^{-1}, However, in a limnocorral field study, fenvalerate concentrations $\leqslant 0.01$ μgL^{-1} had only transitory effects on filter feeding behaviour (11).

OBJECTIVE 3: *To reduce total pesticide input into the environment.*

Eleven grants totalling $125,800 were allocated to this objective. Another study funded in 1982-83 was completed during this period.

In a study on the economics of pest control, first-year results indicated that, in the absence of adequate control measures, production losses due to insects, diseases, and weeds in processing tomatoes and cabbage would be $3623/ha (82%) and $1977/ha (86%), respectively (24).

Continued support was provided for research on development of three pest monitoring techniques. Results over two years indicated that pheromone traps can be used to monitor for variegated cutworm adults. With this technique, it should be feasible to implement a cutworm "warning" system for tomato growers in southwestern Ontario (12). In studies, in northern Ontario, on spruce budworm, different lures, trap designs, and trap densities have now been tested for effectiveness with promising results and predictions of larval populations based on moth collections made the preceding year have generally been satisfactory (17). Forecasters of the two principal diseases of onions were field tested. BOTCAST, used to forecast the timing of the initial fungicide application for botrytis leaf blight, proved satisfactory and is now ready for limited implementation in the onion pest management program. Field testing of DOWNCAST, which is designed to predict timing of fungicide applications for downy mildew control, was hampered by extraordinarily high summer temperatures which delayed disease development. The technique, however, accurately predicted late summer disease development (22).

Current pesticide application techniques leave much to be desired and earlier research has shown that poor efficacy of insecticides applied for corn rootworm control is due, in part, to poor equipment maintenance and calibration. A follow-up study, however, indicated that grower failure to

properly clean application equipment and "caking" tendencies of some rootworm insecticide formulations under conditions of high humidity were not factors influencing application rate variations noted in earlier studies. A minority of growers used calibration tubes; considerable error was found when calibration tubes available in Ontario were used to measure insecticides. In addition to these studies, further work was done to determine the most effective technique for applying corn rootworm insecticides (7).

Continued support was given to several studies aimed at determining the feasibility of developing integrated approaches to pest control. Seed treatments with some organophosphorus insecticides were as, or superior to, current recommendations for root maggot control in onions and radishes. Successful development of this technique would result in a substantial reduction in the amount of insecticide applied for root maggot control (26). In studies on the feasibility of using native parasites and predators for integrated control of the onion maggot, good progress was made in developing mass rearing procedures for two parasite species; in evaluating their susceptibility to currently recommended pesticides; and in assessing their potential to reduce onion maggot populations under field conditions (25). In studies with the spruce budworm, several strains of an egg parasite were evaluated in laboratory and/or field tests to determine the best strain for field release. About 3,000,000 parasites were released in one field trial; over the season budworm egg masses in the experimental area averaged 80% parasitism (10).

Several new integrated pest management feasibility studies were initiated. The possibility of suppressing house fly populations breeding in livestock production facilities through release of commercially available parasites was assessed. Parasite shipments met the standards as to species and number of parasites claimed but when released at recommended rates, percent house fly parasitism (<13%) was too low to merit recommending to producers as a control measure (21). A study also was funded to assess the toxicity of *Bacillus thuringiensis israelensis* to black fly larvae and non-target predator species; a final report on this work is expected in 1985 (16). In another study designed to evaluate the influence of thatch, pH modification, and fungicide treatment on snow mold disease in turfgrass, fungicide treatments at 0.7x recommended dosages significantly reduced snow mold; pH modification alone, or in combination with fungicide treatments, did not result in any significant reduction in snow mold incidence and severity. However, chlorothalonil effectiveness against dollarspot disease of creeping bentgrass was significantly improved when ammonium nitrate was applied to turfgrass prior to inoculation (2). In a study aimed at developing new approaches to disease management in strawberries and stone fruits, a program was devised to monitor distribution and intensity of grey mold on strawberries relative to climatic, cultural, and chemical control practices. Survey data on brown rot occurrence in stone fruits indicated the possibility of widespread distribution of benzimidazole-resistant brown rot strains in the Niagara region (23).

IV. ASSESSMENT

Public pressure has resulted in restrictions on use of a number of important pesticides in Ontario. Suitable alternative control programs were sometimes available, but in other instances suggested methods were not feasible or proved unsatisfactory. In these situations, OPAC has funded research aimed at developing new chemical programs for pest control. Good progress has been made during the past decade on some of these problems, *e.g.*, on biting fly control, but other problems remain.

Vertebrate pests can be a serious problem in urban and rural settings and the Ministry of the Environment has supported research on vertebrate biology and control. The current recommendation for mouse control in orchards leaves much to be desired. Research data obtained over the past two years which indicate that poison bait feeder stations located at intervals throughout an orchard offer a better means of mouse control are encouraging.

Structural pests also pose serious problems in Ontario and the Ministry of Environment has supported research on development of control measures for some of these pests. Control measures for the carpenter ant, one of the more important structural pests, rely primarily on the use of the persistent cyclodiene insecticide, chlordane. If feasible, insecticidal baits would provide a more acceptable approach to carpenter ant control.

The continued erosion in number of available pest control chemicals and lack of incentive to develop new control agents is a matter of serious concern to those involved in pest control aspects of agriculture, forestry, and human health. Progress on solution of two such problems, *i.e.*, identifying alternatives to replace allidochlor which is used for weed control in onions and 2,4,5-T which was used for brush control is being made. These, however, are only two examples of pest control problems which will become apparent over the next decade as a result of decisions concerning pesticide use made during the past decade.

Good progress has been made during the past decade in determining the fate and behaviour of pesticides in the Ontario environment. Environmental residues of the organochlorine insecticides are declining and residues of currently recommended pesticides on major and minor crops are generally well within acceptable levels. As new toxicological data are generated, acceptable residue levels on crops may be revised, as has occurred with the fungicide, captan. Reduced tolerances for this pesticide have forced a reevaluation of some control programs relying on captan use and consideration of the feasibility of developing integrated approaches to disease control.

Pesticide use in public areas, *e.g.*, schoolyards, parks, and roadsides has caused some public concern. Results of a comprehensive two-year research program which show that dislodgeable residues of herbicides and insecticides used for pest control on turfgrass are very low should be useful in allaying public concern over this question.

Corn is one of the most important of the agricultural crops grown in Ontario and pesticides used to control pests of corn represent a substantial part of total pesticide use in this province. The research studies aimed at improving application techniques for corn rootworm control and determining the fate and behaviour of insecticides and herbicides applied to control corn pests represent an important contribution to improvement of corn pest management programs.

Currently recommended pesticides are subject to chemical and microbial degradation in soil and water. Research data which demonstrate the influence which environmental conditions such as soil moisture, temperature, and pH have on pesticide degradation rates illustrate the necessity of conducting residue studies on pesticides used in this province under Ontario environmental conditions. The discovery that soil microbial populations are capable of an adaptation enabling them to rapidly degrade some pesticides in soil has very important crop protection and environmental implications.

A concern of OPAC is that some of the newer water soluble pesticides or their metabolites may contaminate groundwater. Support for research on the environmental behaviour and fate of metalaxyl and disulfoton mirrors this concern. Research data on these and other water soluble pesticidal residues of phorate, terbufos, and aldicarb suggest that while these pesticides are mobile in soil, their potential for groundwater contamination is limited by their short persistence in soil and current use patterns. Nevertheless, this aspect of pesticide behaviour in the environment merits close attention.

OPAC supported research over the past decade has shown that, in general, environmental side-effects resulting from currently recommended pesticides are few and transitory. This trend was again apparent in a study done to determine if the pyrethroid insecticide, fenvalerate, affected the behaviour of filter feeding zooplankton. Even so, continued vigilance to ensure that pesticides do not exhibit serious non-target effects is essential.

Reducing pesticide input into the environment is an important goal. Pesticide use should be justified on the basis of quantitative crop loss data. Results obtained during 1983 clearly illustrate the necessity of controlling pests of processing tomatoes and cabbage. Based on 1981 estimates of crop value in Ontario, the 82% and 86% losses reported in the absence of pest control measures translate into losses of about $40,000,000 and $7,000,000 for processing tomatoes and cabbage, respectively.

One of the most promising approaches to reducing pesticide use involves development of pest monitoring techniques to insure proper timing of pesticide applications. Development of most of the pest monitoring programs currently used in Ontario was initially stimulated by OPAC research support. It is encouraging to note that development of the three monitoring programs for which support was continued in 1983-84 has reached the point where they are now ready, or close to ready, for limited implementation.

Integrated methods of pest control are a commendable long-term objective, but it is important to recognize that such approaches to pest control will be practical in only a few specific instances. These can only be determined by supporting feasibility studies, which ultimately may indicate that a non-chemical or integrated approach to a pest control problem is impractical. Even in cases where alternative approaches to pest control appear feasible, development of such techniques will often require many years of research effort. Nevertheless, progress is being made with important pests such as the house fly, root maggots, and the spruce budworm in identification, mass production, and field evaluation of promising parasites and predators which may have a place in future integrated pest management programs.

The Pesticides Advisory Committee is pleased with the research progress made in 1983-84. The committee recognizes that, with the limited funds available the program can be expected to act only as a catalyst in stimulating support by other agencies for research on pesticides; support which is greatly appreciated. The Pesticides Advisory Committee recommends that the Ministry of the Environment continue to support this productive research program.

APPENDIX I: FORMAT OF ADVERTISEMENT INVITING APPLICATIONS FOR RESEARCH SUPPORT FROM THE ONTARIO PESTICIDES ADVISORY COMMITTEE

January 1983

APPLICATION FOR RESEARCH SUPPORT

The Ontario Ministry of the Environment has a limited amount of funds available for 1983 to sponsor research aimed at: 1) determining potential environmental hazards associated with pesticides currently in use; 2) developing alternative pesticides for those deemed environmentally hazardous and thus restricted in use; and 3) developing alternative approaches to pest control in order to reduce total pesticide input into the environment. Preference will be given to proposals yielding results in a relatively short time, with funds being committed on a yearly basis. Research should be in the context of normal use patterns.

The Ministry invites research proposals in the following areas:

1. Studies on toxicology, persistence, fate and biological significance of pesticides in the environment, and on disposal of pesticides and pesticide containers.

2. Development of information on time which should elapse between dates of treatment and re-entry into treated areas, and on exposure of agricultural workers, licensed exterminators, and the public to pesticides.

3. Reduction of pesticide use through development of effective pest monitoring techniques; alternative integrated or non-chemical methods of control; or improved application techniques.

4. Economics of pest* control.

5. Studies leading to the development of environmentally acceptable pesticides including use on minor crops.

Cont./...

APPLICATION PROCEDURE

Research proposals should be submitted to:

The Chairman
Pesticides Advisory Committee
Ministry of the Environment
Suite 100, 135 St. Clair Ave. W.
Toronto, Ontario
M4V 1P5

Applications should be received by February 28, 1983, and should include the following:

1. Title of project.

2. Name, address and affiliation of applicant(s).

3. Discussion of problem - (Applicants applying for continuation of a grant should include a summary of previous progress).

4. Clear statement of objective(s).

5. Plan for program.

6. Facilities available.

7. Budget - categorize costs as: Personnel - full/time and part/time, Equipment, Supplies, Overhead Costs, Other.

8. Listing of current projects and other sources of funding.

9. Curriculum vitae on principal investigator(s) (if not already on file with the Pesticides Advisory Committee).

Successful applicants must submit an abstract by year's end and present a progress report at the Committee's annual research seminar held each January.

* In the Pesticides Act, S.I. (I) 20, a "Pest" means "any injurious, noxious or troublesome plant or animal life other than man or plant or animal life on or in man and includes any injurious, noxious or troublesome organic function of a plant or animal".

APPENDIX II: RESEARCH PROJECTS SUPPORTED BY THE ONTARIO PESTICIDES ADVISORY COMMITTEE, 1983-84

No.	Applicant(s)	Location	Project Title	$ Amount Granted
1.	Blaine, W.D.	Chemical Research Int.	The efficacy of insecticidal baits in the control of the carpenter ant.	5,000
2.	Burpee, L.L.	University of Guelph	Integrated management of turfgrass diseases in Ontario.	8,000
3.	Chapman, R.A. Harris, C.R.	University of Western Ontario	Behaviour of disulfoton in soil.	10,000
4.	Chapman, R.A. Miles, J.R.W. McLeod, D.G.R.	University of Western Ontario	Persistence and degradation in soil of insecticides recommended in Ontario for corn rootworm control.	14,900
5.	Dekker, J.	University of Guelph	Persistence of thiocarbamate herbicides in soils with and without a history of continuous applications.	10,000
6.	Edgington, L.V.	University of Guelph	The effect of intensity, frequency and amount of rainfall on the movement and persistence of metalaxyl, atrazine and ethion.	8,800
7.	Ellis, C.R.	University of Guelph	Determination of the cause of poor efficacy of insecticides used for control of rootworms.	15,300
8.	Goldberg, M.T.	University of Guelph	A study of the *in-vivo* mutagenesis of captan in the mouse duodenum and the role of glutathione in its prevention.	16,600

No.	Applicant(s)	Location	Project Title	Amount Granted $
9.	Hunter, C.L.	O.F. & V.G.A.	Spray coverage, biological effectiveness and residue levels of captan on strawberries.	6,500
10.	Hubbes, M.	University of Toronto	Feasibility of using an egg parasite for biological control of the spruce budworm.	13,500
11.	Kaushik, N.K. Solomon, K.R.	University of Guelph	The *in-situ* assessment of sublethal effects of the synthetic pyrethroid, fenvalerate, on zooplankton.	8,000
12.	Leili, H.J.	H.J. Heinz Company	Monitoring the variegated cutworm in tomatoes in Kent and Essex Counties to reduce insecticide use.	5,500
13.	Machado, V.S.	University of Guelph	Efficacy of alternative herbicides to allidochlor in onions.	7,000
14.	McEwen, F.L.	University of Guelph	Pesticide residues on minor crops.	17,200
15.	Miles, J.R.W. Tu, C.M.	University of Western Ontario	Influence of environmental factors on the rate of microbial degradation of pesticides in soil.	10,000
16.	Rothfels, K.H.	University of Toronto	Toxicological implications of *Bacillus thuringiensis*, var. *israelensis*.	4,700
17.	Sanders, C.J.	Sault College	Development of sex attractant traps for monitoring changes in low density spruce budworm populations.	12,000
18.	Sears, M.K. Stephenson, G.R.	University of Guelph	Dislodgeable pesticide residues on turfgrass foliage in relation to safe re-entry.	30,000

No.	Applicant(s)	Location	Project Title	Amount $ Granted
19.	Siddiqi, Z.	Chemical Research Int.	Meadow mouse control in orchards.	20,500
20.	Smith, D.W.	University of Guelph	Study of the herbicidal and environmental fate of triclopyr.	10,000
21.	Surgeoner, G.A.	University of Guelph	Biological control of the house fly in livestock production facilities.	13,500
22.	Sutton, J.C. Gillespie, T.J.	University of Guelph	Field testing models for timing fungicides on onions.	16,000
23.	Sutton, J.C. Northover, J.	University of Guelph	Application of epidemiology to reduce fungicide requirements for controlling grey mold of strawberries and brown rot of stone fruits.	10,300
24.	Tolman, J.H. McLeod, D.G.R.	University of Western Ontario	Losses in production of processing tomatoes and cabbage attributable to insects, diseases and weeds.	12,500
25.	Tomlin, A.D. Tolman, J.H.	University of Western Ontario	Feasibility of using parasites and predators in a program of integrated control of the onion maggot.	14,500
	TOTAL			$ 300,300

APPENDIX III: PROJECT REPORTS (ABSTRACTS) ON PROJECTS FUNDED BY THE ONTARIO PESTICIDES COMMITTEE, 1983-84.

1. Blaine, W.D. - *The efficacy of insecticidal baits in the control of the carpenter ant.*

A study was carried out to evaluate the potential of insecticidal baits to control the carpenter ant. The use of various attractants and insecticides was compared to the use of chlordane which is the pesticide normally used for control.

Carpenter ants of the species, *Camponotus herculearus*, were collected from wooded areas in southern Ontario. These colonies were then established in the laboratory. They were supplied with honey and bran as the food source.

Insecticidal baits were made up using molasses as the attractant. The insecticides tested were Ficam, Baygon, Chlordecone, Borax, and Chlordane. None of these baits resulted in colony destruction and little feeding on the baits was seen. When honey and bran were added as a control the ants readily fed on the honey and bran but not on the insecticidal baits. Even when the honey and bran were removed there was little feeding on the baits. Thus it would appear that the ants can detect the insecticide in the bait.

The second area we looked at was the attractiveness of the baits. A choice situation was set up to test the materials. Honey, corn syrup, molasses, and fusel oil were used in the test. The first three materials did not attract the ants over a distance of three feet. The ants readily detected the fusel oil from this distance.

Tests are presently underway to determine over what distance the ants can detect the fusel oil and its degree of attractiveness. We are also investigating whether the ants can still detect the insecticides previously tested in the baits when the fusel oil is present. If the ants can still detect these insecticides, a non-detectable insecticide such as Amdro will be tested.

In the spring baits will be made up using the fusel oil and the most promising insecticides. Field trials of these materials will be conducted.

2. Burpee, L.L., and Goulty, L.G. - *Integrated management of turfgrass diseases in Ontario.*

Experiments were designed to: 1) evaluate the influence of thatch pH modification and fungicide treatments on the incidence and severity of snow molds on creeping bentgrass and annual bluegrass; and 2) determine the impact of nitrogen on the efficacy of fungicides for control of dollarspot disease of creeping bentgrass.

Thatch pH modification. Evaluation of field plots treated with sulfur or various inorganic salts revealed that, with the exception of ammonium sulfate applied at 960 g/100 m^2, no treatment had a significant ($P=0.05$) effect on the incidence and severity of pink snow mold. The ammonium sulfate treatment resulted in a significant ($P=0.05$) increase in the incidence and severity of snow mold. Interactions between fungicide and inorganic salt or sulfur treatments were not significant. However, fungicide treatments alone applied at 0.7X their recommended dosages, resulted in significantly ($P=0.05$) less disease. Sclerotia of the snow mold fungi *Typhula incarnata* and *T. ishikariensis* failed to germinate 5 mos. after burial in thatch treated at 14d intervals with ammonium bicarbonate (200 g/ 100 m^2).

Nitrogen and dollarspot. The influence of the fungicide, chlorothalonil, on the incidence and severity of dollarspot disease of creeping bentgrass was significantly ($P=0.05$) improved when NH_4NO_3 (709 g/ 100 m^2) was applied to the turfgrass prior to inoculation. The enhancement of fungicide efficacy was more pronounced at a low fungicide dosage (15 g a.i./100 m^2) than at higher dosages (30 and 60 g a.i./100 m^2).

3. Chapman, R.A., and Harris, C.R. - *Behaviour of disulfoton in soil.*

Groundwater contamination arising from the mobility of aldicarb and its oxidative metabolites in mineral soil has demonstrated the need to examine the persistence and mobility of alternative insecticides (and their metabolites) of relatively high water solubility. A field study on the persistence of disulfoton and the metabolites formed was carried out for a furrow application of Disyston® 15G in a mineral soil. It included artificially induced high and low rainfall/moisture conditions. Mobility was assessed by measuring the concentrations in both the upper and lower 10 cm of soil. The concentration of disulfoton and its metabolites in potatoes (seed pieces, foliage and new tubers) was also examined. Laboratory experiments on the amount of insecticide leached from wet and dry soil by 15, 30, and 60 mm of rainfall at 0, 1, 2, 3, and 4 wk after treatment are currently underway. The necessity for water persistence studies will be assessed when these are completed.

The persistence of disulfoton in the upper 10 cm of soil was affected by the rainfall/moisture conditions with 3, 6, and 11% remaining at 8 wk in the wet, natural and dry soils, respectively. Disulfoton sulfoxide and sulfone formation and/or retention were greatest in the dry soil (sulfoxide 19% at 6 wk; sulfone 11% at 8 wk) and successively decreased with natural and wet conditions. The formation of these metabolites appeared unusually delayed in this soil. Disulfoton levels in the lower 10 cm of the wet soil (max. 20% of applied at 3 day) suggest movement but the appearance of disulfoton in the lower level of dry soil (ca. 3-5% of applied) indicates the effect may be partly due to sampling. Only traces of sulfoxide or sulfone were observed in the lower level for all three moisture conditions. If these metabolites did form in the upper level of the wetter soils, the results indicate that they were leached below the lower level. Hopefully, more definite results on this aspect of soil behaviour will be provided by the laboratory work in progress.

Disulfoton was more persistent in the soil with potato plants present (ca. 20% remaining at 8 wk) and the sulfoxide and sulfone showed more "normal" behaviour reaching concentrations of 20 and 5% at 2-3 and 3-4 wk, respectively. Disulfoton was the major insecticidal component of the seed piece for the first 6 wk with maximum concentration at 3 wk. The concentrations of sulfoxide, sulfone and oxygen analog metabolites increased steadily during the 8 wk lifetime of the seed piece (max. 8, 7 and 3 ppm, respectively). Disulfoton sulfoxide and sulfone were the major insecticides in the first foliage (ca. 10 ppm each at 4 wk). Their concentrations declined thereafter. Oxygen analog metabolites slowy increased to a maximum of 6 ppm at 8 wk. The foliage was not very toxic (max. 25% mortality at 5 wk) to 2nd instar Colorado potato beetle at any time. New tubers (8 wk) contained 0.15 ppm sulfoxide, 0.23 ppm sulfone and 0.07 ppm oxygen analog sulfone. By week 12 these levels were <0.01 ppm.

4. Chapman, R.A., Miles, J.R.W., McLeod, D.G.R., and Harris, C.R. - *Persistence and degradation in soil of insecticides recommended in Ontario for corn rootworm control.*

In Ontario, insecticides applied for corn rootworm control probably represent the largest use for any one insect pest. To obtain comparative persistence data, a field test was set up including 10 insecticides which are registered or being evaluated for corn rootworm control. The study was set up on microplots using a clay loam soil which had not been previously subjected to pesticide treatment. The granular insecticides were applied at recommended application rates (11.0 - 11.3 g AI/100 m row) to each plot in 3 15 cm bands. Treatments were replicated. After application, the treatments were lightly incorporated by gentle raking parallel to the length of each band. Soil samples (2.5 x 15 cm cores) were taken through the bands at 0, 1, 2, 3, 4, 6, 8, 10, 12, 16, and 20 wk.

It is generally assumed that insecticide residues must remain in the soil at biologically active levels for ca. 8 wk to provide effective corn rootworm control. With exception of CGA 73102, chloethocarb, and chlorfenvinphos, residues of which all declined to ⩽2% of the initial application in 8 wk, the remaining insecticides (chlorpyrifos, fonofos, phorate, carbofuran, disulfoton, terbufos, isofenphos) appeared to be sufficiently persistent (12-66% of the initial application remaining after 8 wk) to meet this guideline. After 20 wk, no residues of CGA 73102, chloethocarb, or carbofuran were detectable in the soil; residues of chlorfenvinphos, chlorpyrifos, fonofos, phorate, disulfoton, and terbufos were all ⩽3% of the initial application. Isofenphos was the most persistent of the 10 insecticides, with ca. 8% of the initial residues carrying over into the following year; these residues would be diluted by normal cultivation practices. Extreme weather conditions during the 1983 growing season (cold and wet from mid-May to mid-June; abnormally hot and dry thereafter) may have influenced the residue picture.

In recent years, there have been reports of erratic performance of corn rootworm insecticides, especially carbofuran. Several theories to explain these control failures have been suggested, including one that soil microorganisms can develop the ability to rapidly degrade some insecticides. Laboratory persistence studies done with field-collected soils with

different histories of carbofuran use have yielded contradictory results. To provide further information on the extent of microbial involvement in carbofuran degradation, we examined carbofuran disappearance in a sandy loam soil having no history of insecticide treatment and the effect of carbofuran pretreatments on subsequent treatments with carbofuran and some other pesticides.

The results indicated that, while numbers of bacteria and fungi in soil were not affected by carbofuran pretreatment, carbofuran degradation rates were greatly increased by as little as one 10 ppm carbofuran pretreatment of the soil. Drastic reductions in carbofuran degradation rates in "activated" soil produced by heat sterilization, freezing, or drying strongly indicated that soil microorganisms were the active agents. Increased degradation rates for a variety of aryl- and oximino-methylcarbamates occurred in carbofuran-activated soil, but this soil did not affect the degradation rates of the thiolcarbamate, butylate, the phenylcarbamate, chlorpropham, or the organophosphorus insecticide, phorate. Further research will be necessary to fully evaluate the significance of this microbial adaptation to the disappearance of carbofuran and other pesticides applied in the recommended manner. Nevertheless, this phenomenon could have very important crop protection and environmental implications.

5. Menkveld, B., and Dekker, J.R. - *Persistence of thiocarbamate herbicides in soils with and without a history of continuous application: Accelerated breakdown of butylate in soils with a history of its use.*

Controlled environment studies were initiated to investigate the sharp decline in weed control with butylate plus R-25788 (butylate$^+$) which was observed at several Ontario farm sites. The 2 sites tested included a silt loam soil (pH 6.7, o.m. 5.3%) treated with butylate from 1972-1983, and a loamy sand soil (pH 7.8, o.m. 1.9%) treated from 1978-1980. Bulk samples of sterilized and non-sterilized (field soil from the 2 locations) were treated with butylate$^+$ and EPTC$^+$ at 3.4 and 6.8 kg/ha. At 7 day intervals after treatment, Japanese millet (*Echinochloa frumentacea*) was planted into soil aliquots taken from the treated bulk samples. Seven days after planting, shoot fresh weights were obtained at each of the 6 harvest dates. The experiment was designed as a completely randomized four-way factorial [soil type (2), soil microflora (2), herbicide (2), rate (3)]. The experiment was replicated 5 times, and was repeated. On the basis of the experimental results several statements can be made. Butylate$^+$ was less effective than EPTC$^+$, irrespective of soil type and microflora. In field soils butylate$^+$ lost all weed control after 3 weeks, EPTC$^+$ after 5 weeks. Both herbicides remained effective in sterile soils after the last harvest, 6 weeks. The herbicides, applied at the low rate, gave better control in the loamy sand. The high rates were more effective than the low rates but there was no difference between soil types. The data re-emphasize the importance of soil microbes in the degradation of these herbicides and also indicate that preferential breakdown of butylate$^+$ may occur in soils preconditioned with this herbicide. Initially, weed control was better in the loamy sand but this difference disappeared after 3 weeks. Users have reported that in as little as 3 years of continuous butylate$^+$ application, a soil may become preconditioned and show decreased weed control. The experiment indicates that this condition may last in soils for at least 2 years after the last application.

6. Sharom, M.S., and Edginton, L.V. - *The effect of intensity, frequency and amount of rainfall on the movement and persistence of metalaxyl, atrazine, and ethion.*

A laboratory study on the effect of sequential periods of rain and drying on the movement of metalaxyl in soil indicated that the fungicide was leached with each rainfall but moved upward during the drying cycle. A field study was conducted to determine whether this phenomenon occurs under the natural conditions. Ethion, atrazine and metalaxyl with water solubilities of 0.6, 33 and 7000 ppm respectively, were selected for this investigation. No "Yo-Yo" effect was observed in the field study. Failure to observe the "Yo-Yo" effect under field conditions may be attributed to several factors such as the sampling technique, pesticide formulation, rate of water evaporation from the soil, rate of pesticide degradation, etc.

7. Ellis, C.R., and Beattie, B. - *Determination of the cause of poor efficacy of insecticides used for control of rootworms.*

A) Problems in cleaning and calibrating granular applicators.

A follow-up survey of the corn growers originally surveyed in 1983 showed that 74% cleaned their applicator hoppers after applying insecticides for corn rootworms, but only 68% removed the hoppers to clean the metering slots. Although cleaning was undoubtedly important, failure to clean did not account for the variations in rates which were identified in the original survey. Most growers used water to clean the hoppers, however, 16% used compressed air and 22% just drained out the insecticide. Only 39% of growers used respirators when applying granular pesticides or cleaning equipment.

A test showed all clay-based formulations were somewhat hydrophilic and differed in their sticking and caking characteristics under high relative humidity. Also, 31% of growers reported problems with application rates after several days without use. These growers all subsequently cleaned their equipment. Variation in rates in the original survey, however, was not associated with pesticide formulations.

Only 67% of growers had heard of calibration tubes and only 30% had ever used them. One could argue that better application rates would result if calibration tubes were more widely available and used. However, considerable error was found when using tubes available in Ontario to measure insecticide in 1983. Error ranged from a 6.7% underestimate to a 15.8% overestimate. Results also varied ca. 10% depending on settling.

Over 100 calibrations were done on an application of one corn planter at Guelph. Analysis of variance on data from three calibration distances, three levels of insecticide in the hoppers and on two insecticides showed that application rate was not affected by the amount of insecticide in the hopper. However, application distances of less than 100 meters resulted in ca. 5% underestimation of rates.

The long-term goal of this research is to improve the on-farm application of granular pesticides. Research is still on-going with the immediate goal of producing a fact sheet for Ontario corn growers on cleaning and calibrating application equipment.

B) Effect of banding and incorporation on efficacy of rootworm insecticides.

Granular insecticides are recommended each year by the Ontario Ministry of Agriculture and Food (OMAF) for the control of corn rootworms. OMAF recommendations call for applying these insecticides in 15 cm bands and incorporating them into the soil. Application in 15 cm bands is practised by 91.8% of growers while incorporation is practised by only 23.5%. The object of the research reported here was to determine whether these factors influenced pesticide efficacy and thus accounted for some of the reports of poor on-farm rootworm control.

Different methods of application were tested on three farms in 1983 where large populations of rootworms were expected. Eighty, four-row plots were used on each farm to test three insecticides applied either without spreaders or in 15- or 30-cm bands and in each case with and without incorporation. Treatments, including two checks, were replicated four times in a randomized block design.

The root systems of six corn plants from each plot were removed in 15 cm cubes of soil in July. Rootworms were extracted from these samples at Guelph to estimate efficacy. Roots were also rated for rootworm injury following the 0 to 6 rating used in the corn belt. The percentage of goosenecked plants was determined in September as another measurement of root injury. The yield of dry shelled corn was obtained in early October from 7 m of a centre row of each plot.

Because of hardened soil, rootworm counts were possible at only two locations. At both sites, the insecticides differed in efficacy but there was no effect from banding or incorporation. At the third location, where larval counts were not possible, there was significantly more goosenecking where drag chains were used to incorporate carbofuran. None of the other parameters were significantly different at any location.

We now have three years of data on the effect of banding and incorporation. Banding had a significant effect on 2 of 5 tests with the 15 cm band being most effective. Drag chains had a significant effect in 1 of 5 tests where carbofuran was rendered less effective by the chains. A final report involving both experiments with precision equipment and with commercial equipment is under preparation.

8. Goldberg, M.T. - *A study of the in-vivo mutagenesis of captan in the mouse duodenum and the role of glutathione in its prevention.*

This project was funded in the latter part of 1983. A progress report is expected in 1985.

9. Hunter, C.L. - *Spray coverage, biological effectiveness, and residue levels of captan on strawberries.*

A change of allowable captan residues on strawberry fruit from 25 ppm to 5 ppm led to uncertainty amongst growers and researchers as to what changes, if any, in the recommended spraying procedures, would be necessitated by such a change (in allowable residues).

This study was made to observe the spray coverages achieved by various sprayers and to relate these to Captan residues. These included low and high pressure boom sprayers, a boom sprayer with drop nozzles, air-blast, and irrigation application systems. Spray coverages (using a 0-10 scale) ranged from 2.5 to 4.8, with no discernable coverage rating observed in the irrigation trial, due to the washing action of the high water volume. An important feature observed in the coverage study was the range in coverage on each berry. A low and high reading per berry showed that a range of 52.9 to 99.5 per cent of berries had an inadequate (<3) rating on part or all of its surface. Thus, all of these berries would be "at risk" to infection.

Captan residues ranged widely (5.3 to 40.7 ppm) at and between locations. No consistent correlation can be made to spray coverage, rainfall, irrigation or time. However, the overall residues, except those in the irrigation application, were consistently above the 5 ppm legal limit. This despite rain and irrigation. Residues in the irrigation trial were quite low, 2.1 to 4.3 ppm, but still higher than those reported from other studies. It is very important to point out that time of sampling, handling and storage of samples must play a role in these differences. All berries in this study were hand picked, individually, and either frozen or delivered immediately from the field to Dr. Frank's lab.

It is important to consider that berries getting all or part of their surface poorly sprayed, will not achieve protection from the botrytis fungus. In work done by Dr. John Northover, berries given uniform coverage and a resulting captan deposit equal to 3.5 ppm, disease control was only in the order of 15%. Further work will be done, and it is felt that 7-10 ppm will result in adequate (≥80%) disease control.

Due to the range in coverages on individual berries, to achieve sufficient captan on the poorest covered sides, (7-10 ppm) the "average" berry taken as a whole for sampling purposes could be expected to have residues 3-4 fold higher.

None of the sprayers examined could achieve uniform coverages. Unless more captan is applied to ensure adequate deposit on the hard-to-hit target, the berry is still at risk. Alternative available fungicides would have the same problem. The only glimmer of hope would be a formulation change allowing more improved sticking and redistribution properties such as with a product like Bravo or Difolatan. This does not appear likely for the near future.

10. Hubbes, M., and S.M. Smith - *Feasibility of using an egg parasite for biological control of the spruce budworm.*

Ground releases of *Trichogramma minutum* were carried out on 7, 14 and 21 July, 1983 in Hearst, Ontario. Approximately 3 million female parasites were released on an area of 0.25 hectares when taking into consideration rate of release, emergence, and sex ratio. Sentinel egg masses of spruce budworm, placed in the field and changed twice weekly from 18 June to 17 August, were used to monitor parasitism.

No natural parasitism was observed in the control plots. Maximum parasitism following the first release was 82%, following the second release, 87%, and following the third release 91% of the egg masses. These parasitism levels were maintained in those plots which received two or three releases. Multiple releases, therefore, did not increase parasitism levels but sustained parasitism for a one week period following release.

Over the season, the number of eggs parasitized within each egg mass averaged 80%. As the number of eggs per egg mass increased, the percentage of eggs parasitized within that mass decreased in a linear relationship. The number of *T. minutum* progeny emerging from each parasitized budworm egg averaged 2.3 throughout the season.

The number of eggs parasitized was dependent upon the height at which the sentinel egg mass was placed, with parasitism averaging 82% at 3.25 and 2.25 meters and 76% at 1.25 meters. Generally, those parasites emerging earlier moved into the upper canopy while those emerging later remained at the lower level. Horizontal dispersal, measured with single point releases was local. Most parasites were collected directly above the release site or within 5 meters. This movement was influenced by wind conditions at the time of release.

Sleeve cages in the field indicated that: 1) there was no difference in parasitism between eggs on balsam fir or white spruce; 2) there was no difference in parasitism between *T. minutum* emerging from Mediterranean flour moth or Angoumois grain moth; 3) strains from different geographical locations varied in their effectiveness in the field; 4) the relationship of parasitism by *T. minutum* on budworm egg masses was sigmoid with increasing parasitism at increasing parasite density; and 5) parasitism increased as host density increased up to 5 female *T. minutum*/egg mass after which parasitism did not change significantly with increasing host density.

Laboratory studies suggested that strains of *T. minutum* reared from Vineland and Rogers laid fewer eggs than the Plummer strain which is currently used for inundative releases. Strains from Grundy and Rogers, however, produced more female progeny than the other strains and consequently their rate of increase values (r) were higher. It is recommended that Grundy strain be used for future inundative releases.

Ten enzyme systems have been studied with starch gel electrophoresis with differences being observed in five systems: IDH, 6-PGD, G-6DH, α-GDH, and EST. It remains to be seen if these biochemical differences can be correlated with biological differences reported above.

All strains of *T. minutum* emerging from spruce budworm eggs performed better in laboratory experiments than those emerging from flour moth eggs, with two to three times as many eggs laid, four times as many progeny produced, more female progeny, greater emergence, and higher rates of increase (r).

Further work is required to determine at what level of release maximum parasitism can be achieved, what is the best method of release, and what is considered an 'effective' level of parasitism. The feasibility of inundative releases of *T. minutum* should be viewed in the context of integrated control for the spruce budworm.

11. Day, K., Kaushik, N.K., and Solomon, K.R. - *The in-situ assessment of sublethal effects of the synthetic pyrethroid, fenvalerate, on zooplankton.*

Laboratory and field experiments were conducted with the radioactive (14-carbon) alga, *Chlamydomonas* sp., to determine the effect of different concentrations of the insecticide, fenvalerate, on the filtering activity of three species of zooplankton - *Diaptomus oregonensis*, *Ceriodaphnia lacustris*, and *Daphnia galeata mendotae*.

Laboratory Studies

In the laboratory, 50-100 animals of each species collected from Lake St. George were exposed in triplicate to 5.0, 0.5, 0.1 and 0.01 μg L^{-1} of fenvalerate. Filtering activity in all three species of zooplankton ceased at concentrations of 5.0 and 0.5 μg L^{-1} after a 2-hour period of exposure to the insecticide. The filtering rates of *Diaptomus oregonensis* and *Daphnia g. mendotae* decreased significantly upon exposure to 0.05 μg L^{-1} of fenvalerate but were similar to controls at 0.01 μg L^{-1}. The filtering rate of *Ceriodaphnia lacustris* was not reduced at 0.05 or 0.01 μg L^{-1} when compared to the control animals.

Field Studies

In the field, a large volume limnocorral (125 m^3) was treated with fenvalerate on 13 July 1983 and 15 September 1983 with a surface application to produce nominal concentrations of 0.1 μg L^{-1} and 0.01 μg L^{-1} respectively. Filtering rate determinations were performed at 1m, 2m and 3m depths in the water column both before treatment and at 0, 1 and 4 days following treatment using a 10 L Haney type grazing chamber. Similar grazing experiments were performed in an untreated enclosure.

Treatment of the enclosure with 0.1 μg L^{-1} of fenvalerate did not decrease filtering activity on the day of treatment at all three depths. However, the filtering rates of all three species of zooplankton were decreased the day following treatment. At 4 days following treatment, *C. lacustris* and *D.g. mendotae* were not available in sufficient numbers in the treated limnocorral to determine rates of filtration. The filtering rate of *D. oregonensis* returned to levels similar to pretreatment by day 4 following treatment.

Fenvalerate had a significant effect on the populations of species over time. Abundance (measured as numbers of animals per litre in the water column) of *Ceriodaphnia lacustris* decreased for approximately three weeks following treatment. The population of *Daphnia g. mendotae* decreased following treatment and failed to recover. *Diaptomus oregonensis* appeared to be unaffected by the treatment. The untreated enclosure did not show significant changes over the same time period in either filtering rates or abundance of species.

Treatment of the enclosure on 13 September 1983 with 0.01 μg L^{-1} of fenvalerate caused the filtering rate of *D. oregonensis* to decrease for one day following treatment.

The filtering rate of *C. lacustris* was not affected by this level of treatment. Populations of both species in the enclosure did not decrease following treatment.

It can be concluded that concentrations of fenvalerate at 0.1 μg L^{-1} or less have only short term effects on species of filtering-feeding zooplankton. In addition, species-specific effects are apparent.

12. Makey, S.R., and Leili, H.J. - *Monitoring the variegated cutworm in tomatoes in Kent and Essex Counties to reduce insecticide use.*

In 1983, pheromone trapping proved to be as reliable and effective as black light trapping, for monitoring variegated cutworm moths. Similar results were obtained in 1982. An increase in moth counts suggested the optimum time for growers to begin monitoring their fields for larvae on a regular basis. The degree day model proved accurate in 1982 for predicting peak moth flight, but could not be applied in 1983.

We are recommending that this pest monitoring system be adopted as a commercial practice for our tomato growers, in order to reduce variegated cutworm damage, and to reduce the pesticide load in tomatoes.

13. Machado, V.S. - *Efficacy of alternative herbicides to allidochlor in onions.*

Two field trials were conducted at the Muck Research Station, Bradford using the cv 'Rocket' direct seeded, to assess alternative herbicides to allidochlor. Herbicide treatments using preemergence (pyramin, oxyfluorfen), loop stage (cyanazine, oxyfluorfen) 2 fully developed leaf and later (oxyfluorfen, pendimethalin, ioxynil, sethoxydim, fluazifop, dichlofop-methyl) were evaluated on broadleaf and grass weeds. Effective weed control was recorded with cyanazine at 1.6 kg/ha (onion loop), pendimethalin 3.0 kg/ha (grass 2 leaf), oxyfluorfen 0.12 kg/ha (onion 2 fully developed leaf) followed by subsequent repeat applications of oxyfluorfen and later, prior to bulbing, with ioxynil at 0.45 kg/ha. All the grass herbicides tested proved effective. Some crop phytotoxicity was recorded with cyanazine and oxyfluorfen initially, but later the onion plants recovered.

Tolerance of onion seedlings to oxyfluorfen was evaluated in controlled environment growth rooms. ED_{50} values were derived by determining the dosage required to reduce by 50% the dry weight of onion seedlings sprayed at the various growth stages. Based on these values, tolerance to oxyfluorfen increased by 2 fold between the loop and flag stage, and by 14 fold between the flag and one fully developed leaf stage. Retention of oxyfluorfen spray with a water soluble dye Eosin B was assessed under field and growth room conditions. Spray retention on a dry weight basis decreased about 20 and 40% between the loop/flag and flag/one fully developed leaf stages, respectively. Epicuticular wax on the surface of onion leaves on a dry weight basis increased by 28% between the loop/flag stages and by 68% between the flag/one fully developed leaf stages.

14. McEwen, F.L., Ritcey, G., and Frank, R. - *Pesticide residues on minor crops.*

The shortage of effective fungicides for disease control presents serious problems for producers of many fruits and vegetables. To improve the opportunity to have effective materials registered, the fungicide chlorothalonil was applied to cos, leaf and head lettuce, and celery and residues determined at 1 to 14 days after 3 applications. Iprodione and metalaxyl in combination with mancozeb were also applied to head lettuce and residues determined. Residues of the insecticide acephate were analyzed in green bush beans (for corn borer control); phosmet in carrots (for carrot weevil control); and cyfluthrin, permethrin, deltamethrin, cypermethrin and carbofuran on strawberries (for clipper weevil control).

In seeking effective insecticides for carrot rust fly control, granular formulations of chlorfenvinphos, chlorpyrifos, fonofos and carbofuran were applied to carrots at seeding and residues determined on bunching carrots (86 days) and mature roots (122 days).

Concern with contact with the fungicide captan in "pick-your-own" operations required an evaluation of the residues transferred to workers in picking captan treated strawberries. Residues were determined on gloves, sleeves and cotton leggings after the wearer had picked captan treated strawberries for various times. In addition, residues were determined on ripe fruit, on ripe fruit plus calyx, on leaves and on the straw used as mulch. Captan residues were also studied on greenhouse and field tomatoes at various intervals after treatment.

Results were given to the chemical manufacturers and to registration authorities. In addition, the results were presented in ECPUA reports.

15. Miles, J.R.W., and Tu, C.M. - *Influence of environmental factors on the rate of microbial degradation of pesticides in soil.*

A study on the influence of moisture on the persistence of pesticides in soil, using chlorpyrifos and chlorfenvinphos as model compounds, was completed. Tests were done using sterile and natural mineral (sandy loam) and organic (muck) soils at 4 moisture levels: air-dry, and 20, 40, and 60% of moisture holding capacity (MHC) at 28°C. Both insecticides were fairly stable in sterile soils with ⩾50% remaining in soil at all moisture levels after 24 wk. In mineral soil, chlorpyrifos disappeared rapidly from air-dry soil and slightly less rapidly from the 3 moist soils. In contrast to chlorpyrifos, chlorfenvinphos was most stable in air-dry mineral soil. In moist sandy loam, disappearance rates were similar at 20, 40, and 60% MHC, but in moist muck, its disappearance rate was proportional to moisture content. *Cis-* and *trans-*chlorfenvinphos disappeared at the same rate in sterile soils, but in natural soils the *cis-*isomer disappeared twice as fast, suggesting specific microbial degradation.

To study the influence of pH on the rate of pesticide degradation in soil, a technique was devised enabling adjustment of soil pH to selected levels and maintenance of those pH's for several weeks. Under the experimental conditions used, carbofuran persistence in soil was pH-dependent - at pH 4, 80% of the initial application was still present in soil after 3 wk, as compared to 44% at pH 7. At pH 10 only 7% and 2% of the initial applications were present after 1 and 3 wk, respectively.

Results of this and earlier OPAC supported research clearly indicate that soil temperature, moisture and pH can have an important influence on the rates of chemical and biochemical degradation of pesticides in soil.

16. Rothfels, K.H. - *Toxicological implications of Bacillus thuringiensis, var. israelensis.*

No progress was reported on this study in 1983-84. A final report is expected in 1984-85.

17. Sanders, C.J. - *Development of sex attractant traps for monitoring changes in low density spruce budworm populations.*

Field trials in 1980 and 1981 led to the conclusion that sticky pheromone traps were not suitable, and as a result various types of non-sticky traps were tested in which the insects are killed by plastic impregnated with insecticide (*e.g.*, Vapona strips).

Moth catches in 1982 in 23 locations in northwestern Ontario showed good correlation with larval populations over a wide range of population densities using a 'home-made' design of non-sticky trap. Tests of commercial lures showed considerable variation in quality.

To confirm the 1982 results the same 'home-made' traps were deployed again in 1983 in the 23 plots in northwestern Ontario. The correlation between moth catch and larval populations gave an R^2 of 51%, not as good as the 77% in 1982, but still useful. With data from both 1982 and 1983 it was possible to determine how accurately the moth catches in 1982 forecast the larval populations in 1983. The R^2 was 62%, again quite encouraging. Another question is how many traps were required per location; although 5 have been used in the past, reduction to 3 would save time and money. Correlation between catch/trap in clusters of 3 and 5 gave an R^2 of 93% implying that a 3 trap cluster is as good as 5.

Recognizing that a commercial trap would be more appropriate for extensive survey work than a 'home-made' design, 4 commercial types of non-sticky trap were obtained in 1983. Due to limitations in manpower and money it was not possible to deploy all the traps in all locations. However, sufficient data were obtained to indicate which design was best. It now remains to test this design in 1984 over the full range of population densities before recommendation for its widespread, long-term use, can be made.

Comparative tests of the 3 commercial lures with the 'home-made' polyvinyl chloride lures indicated much better quality control than in 1982, and with further technical refinement it is probable that the 4 formulations will be virtually interchangeable.

18. Sears, M.K., and Stephenson, G.R. - *Dislodgeable pesticide residues in turfgrass foliage in relation to safe re-entry.*

A) Bowhey, C.S., Thompson, D.G., Sears, M.K., Stephenson, G.R., and Sirons, G. - The persistence of granular and liquid formulations of 2,4-D, diazinon, and Killex® on turfgrass.

Field experiments were conducted to determine the persistence and dislodgeability of granular and liquid formulations of 2,4-D amine, diazinon, and Killex on turfgrass. Dislodgeable residues were estimated by vigorously wiping a 1 m^2 plot with a moistened cheesecloth. Rainfall and daily temperatures were monitored throughout the sampling period.

Results indicated that only low levels of granular and liquid diazinon were dislodged at "0 time" (1% and 0.08% of total chemical applied respectively). The dislodgeable fraction of both formulations decreased rapidly to negligible levels after Day 2.

In a comparison between liquid and granular formulations of 2,4-D amine, dislodgeable residues at "0 time" were 2.7% and 0.165% respectively. By Day 3, residues from either the "sprayed" or "granular" plots had decreased to less than 0.01%. In a study where sprays and granular applications of Killex (2,4-D + mecoprop + dicamba) were compared, dislodgeable residues at "0 time" were 7.8% and 2.4% for 2,4-D amine, 7.5% and 2.7% for mecoprop amine, and 1.2% and 0.4% for dicamba amine, respectively. Dislodgeable residues of 2,4-D declined to less than 1% with either formulation by Day 5. There was a more rapid disappearance of mecoprop and dicamba with dislodgeable residues decreasing to less than 1% by Day 3 and Day 2, respectively.

Although dislodgeable residues are very low with all of the formulations studied, they were significantly lower with the granular formulations, particularly on the day of application.

B) Sears, M.K., Bowhey, C.S., Stephenson, G.R., and Braun, H.E. - Recovery of diazinon, chlorpyrifos, and isofenphos after application to turfgrass.

Diazinon and chlorpyrifos are insecticides commonly applied to turfgrass in public areas such as parklands, school yards and parking strips, and to home lawns and other private areas. Isofenphos, a probable replacement for chlordane in grub control, may be used by licenced applicators on both public and private lands. The degree to which the public may come into contact with these toxic chemicals is under review. The nature of this project was to determine the dislodgeable fraction of these insecticides that remained following a standard application to turfgrass.

Plots of turfgrass, mainly Kentucky bluegrass, were treated with either diazinon 12.5% EC at 4.0 kg AI/ha, chlorpyrifos 40% EC at 2.0 kg AI/ha, or isofenphos 22.5% EC at 2.0 kg AI/ha. Five replicates of each treatment were applied on May 25, 1983. Immediately following application, the dislodgeable fraction on 1 m^2 was removed by vigorous wiping with cheesecloth pads fastened to boots worn by one of the investigators. This procedure was repeated 1, 2, 5, 7 and 14 days after treatments were applied. Cores (10 cm diam.) of turfgrass were also taken immediately after application and at 1, 2, 5, 7, and 14 days following application.

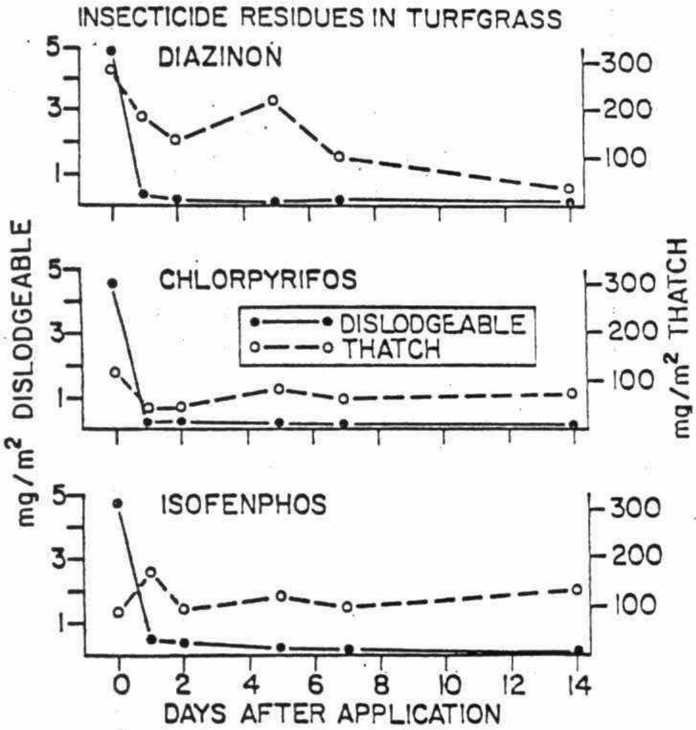
Insecticide residues in the cheesecloth pads were extracted in solvent and analyzed using gas-liquid chromatography with n/p flame photometric detection. Samples of thatch were weighed, macerated and extracted in solvent, and a 10 ml aliquot removed for analysis as described above.

Recovery of dislodgeable residues of each of the insecticides declined rapidly after the day of application. Immediately after treatment residues of diazinon, chlorpyrifos and isofenphos were 1.8, 2.7 and 5.7 percent, respectively, of the amount recovered in the thatch (Table 1). In all cases, by 1 day following application, dislodgeable residues declined to less than 1 percent of the amount recovered in the thatch. As the experiment progressed, dislodgeable residues of all insecticides rapidly declined to negligible amounts while residues of diazinon remaining in the thatch declined more slowly (Fig. 1), and those of chlorpyrifos and isofenphos did not decline significantly over the 14 days of the test.

TABLE 1. Dislodgeable residues of 3 insecticides immediately following their application to turfgrass.

Insecticide	Rate (kg AI/ha)	mg/m^2	As a % of thatch
diazinon	4.0	5.0	1.8
chlorpyrifos	2.0	2.2	2.7
isofenphos	2.1	4.6	5.7

FIGURE 1. Insecticide residues extracted from cheesecloth wipes and from thatch of treated turfgrass.



The significance of those amounts of insecticide residues that were dislodged immediately following application cannot be overlooked, but the rapid decline of such residues greatly reduces the hazard that recently treated turfgrass surfaces might pose.

19. Siddiqi, Z. - *Meadow mouse control in orchards.*

A study to evaluate poison bait feeder stations for control of the meadow mouse in Ontario apple orchards was initiated in the fall of 1981. Various anticoagulant rodenticides and 2% zinc phosphide on cracked corn, the most commonly used rodenticide, in the bait stations were compared with the conventional fall broadcast application of zinc phosphide.

Meadow mouse populations in the experimental plots, located at four locations, was estimated by live trapping in fall, 1981, spring and fall, 1982, and spring and fall, 1983. Tree damage was recorded as percentage of trees girdled in spring, 1982 and 1983. The bait stations were cleaned and refilled in the spring and fall of each year.

A sharp decline in the mouse population was observed in the spring of 1982, in all the treatments, from the levels recorded in the fall of 1981. The mouse population increased slightly in the fall of 1982 and during the spring and fall, 1983 remained at very low levels. During 1982, significantly lower numbers of mice were found in the bait station

plots than the broadcast plots, while no such differences were recorded in 1983. Tree damage during the winter of 1981-82, recorded as percentage trees girdled in spring, 1982, was significantly less in the bait station plots than in the broadcast application plots. During the 1982-83 winter there was no tree damage by meadow mice in any of the experimental plots as revealed by spring, 1983 tree girdling data.

The sudden decline in meadow mouse population in 1983 and absence of tree damage during the winter of 1982-83 may be attributed to two factors: - a natural low peak in the 3-4 year cyclic high peak in the mouse population; and an exceptionally mild winter and less than normal snow cover.

The study will be concluded after estimating the mouse population and recording tree damage in the spring, 1984. However, it is already apparent, from the available data, that any of the rodenticides tested in the bait stations maintaining a rodenticide supply throughout the year offered better meadow mouse control than a single broadcast application of the 2% zinc phosphide on cracked corn in the fall.

During 1983, another part of the study was to test the residual toxicity of 2% zinc phosphide (Waxed Mouse Bait), the most commonly used rodenticide applied as broadcast application in the fall. Samples of the rodenticide were collected at 3, 6, 9, 12, 15, and 18 days after the four dates of broadcast application of October 17, 24, 31, and November 7, 1983. These samples were offered to wild house mice for 3 days under choice and no-choice feeding situations in laboratory cages. It was found that the loss in toxicity was related to the amount of rainfall after broadcast application and that the house mice did not prefer the zinc phosphide when an alternate food source was available.

20. Smith, D.W., and Jotcham, J.R. - *Study of the herbicidal and environmental fate of triclopyr.*

Studies were initiated in the summer of 1982 to examine some environmental properties of triclopyr, ((3,5,6-trichloro-2-pyridyloxy-acetic acid)). There were two main research thrusts. First was an examination of soil behaviour such as mobility, residues, and persistence. The second line of research was on the impact on a plant community along a hydro right-of-way (ROW).

Soil mobility studies were performed using intact soil columns, disturbed soil columns, and soil thin-layer chromatography (TLC). Forest soils were obtained from both northern and southern Ontario, and included a sandy podzol, a clay gleysol, an organic soil, and a loam luvisol. Studies with the intact columns indicated that the top organic horizons were more effective in preventing triclopyr movement than were lower horizons. Soil TLC permitted a study of comparative mobility of triclopyr, 2,4-D, and picloram. Preliminary results indicated that triclopyr was more mobile than 2,4-D, but was less mobile than picloram, in all the horizons tested.

Plots for triclopyr residue analysis were treated in July, 1982. Both soil and vegetation were sampled at intervals throughout the rest of the year. The residues in vegetation were much higher than those in soil. The soil was also sampled in the spring of 1983 and small but measurable residues were detected. Persistence tests, using a soybean bioassay, showed that triclopyr was much less persistent than picloram, and that triclopyr was not significantly different from 2,4,5-T in persistence.

The impact of triclopyr on a plant community was studied along an Ontario Hydro ROW in Milton, just west of Toronto. Triclopyr ester was compared with the herbicide usually used in such circumstances, a 2,4-D and 2,4-DP formulation. Over 100 species were inventoried for density, cover, and frequency. The results indicated that triclopyr was more efficient for control of white ash and sugar maple than was 2,4-D/2,4-DP. Most grasses were resistant to triclopyr but some damage to smooth brome grass was indicated. Species showing an increase after either herbicide treatment included Kentucky bluegrass, common mullein, and climbing nightshade.

Computer programs for multivariate analysis were applied to the vegetation data. Both Twinspan (a hierarchial polythetic divisive technique) and Decorana (an ordination technique based on reciprocal averaging) showed that the overall effect of triclopyr was quite different than that of the 2,4-D/2,4-DP. Not only the magnitude, but also the direction of floristic change was different. These computer techniques graphically display the spatial relationships between plots, based on floristic composition. They could be very valuable in studying the comparative effects of herbicides on the rate and direction of plant succession in a long-term study.

21. Surgeoner, G.A. - *Biological control of the house fly in livestock production facilities.*

Using sentinel pupae, natural parasitism of house fly pupae was evaluated in five types of livestock facilities: horses, poultry, beef and swine. In non-release sites overall percent parasitism of house flies based on over 16,000 pupae was less than 2%. The primary parasite was *Nasonia vitripennis.*

Shipments of commercially available parasites produced by AIM, Inc., Alabama and marketed through AIM Canada were also evaluated. Shipments of 10,000 parasites could be purchased and delivered for ca. $20.00. The shipments were found to contain primarily the parasite advertised, *i.e., Muscidifurax* spp. or *Spalangia enduis* and in the numbers advertised. Shipments were reliable as to supply, delivery date with an overall parasite emergence of ca. 65%. We found the company to produce a reputable product.

Preliminary releases of parasites were made on dairy, swine and poultry farms. Parasites were released weekly at commercially recommended rates, *i.e.,* one parasite per chicken in poultry and 10,000 parasites per barn per week in a standard dairy and swine operation. Overall parasitism achieved (based on over 12,000 pupae) was less than 13% with highest values obtained in the swine facility. Parasites cannot currently be recommended to producers because of this low efficacy.

The parasite *Nasonia vitripennis*, a contaminant of less than 3% in shipments, performed as well as the commercially released parasites *Muscidifurax* and *Spalangia enduis*. This parasite appears more attuned to our climatic conditions and will be evaluated at commercial release rates in 1984.

22. Sutton, J.C., Gillespie, T.J., Rowell, P.M., and James, T. - *Field testing models for timing fungicides on onions.*

Forecasters of two principal foliar diseases of onions were tested in the field during 1983. BOTCAST, a forecaster of botrytis leaf blight of onion, has applications in timing the initial fungicide application for managing leaf blight. DOWNCAST, a forecaster of downy mildew indicates when fungicides should be applied for mildew control. These forecasters were developed over the past several years but required validation under a range of conditions in the field before implementation by growers.

BOTCAST was tested in onion plots at three locations: Arkell (near Guelph), Thedford Marsh (in cooperation with Agriculture Canada) and at the Muck Research Station (Holland Marsh, with cooperation of G. Ritcey, and staff of Muck Station). Weather factors (leaf wetness duration, temperature and relative humidity) were monitored at hourly intervals at each site beginning at crop emergence. Weather data were logged using two types of microprocessor-based data recorders: Datapods (Omnidata, Utah); and a recorder produced by Crop Technologies Inc., Waterloo, Ontario. The latter is the more practical instrument for disease management purposes and features a printer on which leaf wetness duration, mean temperature of wet period and other important variables are recorded. At Arkell, a CR-21 micrologger and 8 weather sensors also were operated. Disease progress and numbers of dead leaves were monitored at weekly intervals in all plots. Plots at the various locations received no sprays, or were sprayed according to the regular grower's regime, or were sprayed every 7 days beginning at BOTCAST threshold 1 or threshold 2.

BOTCAST was effective for timing initial sprays at all locations, but one modification to the model was found necessary. A factor for effects of high temperature (temperatures were unusually high in 1983) was included in the model. The modified BOTCAST predicted disease threshold 1 (total of 4 to 8 lesions on lower three leaves) when 20 to 30 "disease severity units" were accumulated at each location. BOTCAST predicted disease threshold 2 when 30 to 40 "disease severity units" were accumulated. Disease severity units were accumulated daily according to favorableness of weather factors for sporulation and infection. Threshold 1 is a warning threshold, and threshold 2 indicates that spraying should commence. Sprays timed according to threshold 2 controlled blight effectively. The first spray was required 7 to 10 days before rapid disease increase was observed at all locations. When the latent period of 2-3 days is accounted for, BOTCAST allowed a "safety period" of about 7 days. This period could be shorter in some seasons. When fungicides were initiated at threshold one, 2, 3 and 1 sprays were saved at Arkell, Thedford, and the Muck Station, respectively. The savings for threshold two were 4, 5, and 5 sprays. BOTCAST is now ready for limited implementation in the Pest Management

Program at the Bradford area marshes. We also have a request from Cornell University for permission to test BOTCAST in Orange County, New York.

DOWNCAST was evaluated at the Cambridge Research Station. Six fungicides or fungicide combinations were timed according to a single threshold of DOWNCAST in 3 m x 3 m onion plots arranged in a randomized block design. Ridomil-mancozeb was timed according to three different thresholds of disease (after 3, 5, or 7 infection periods). DOWNCAST accurately predicted late development of disease (31 August - 15 September). High temperatures blocked disease progress prior to about 20 August. Extraordinarily high temperatures during most of the summer precluded a realistic evaluation of fungicide effectiveness when timed according to DOWNCAST.

23. Sutton, J.C., and Northover, J. - *Application of epidemiology to reduce fungicide requirements for controlling grey mold of strawberries and brown rot of stone fruits.*

A) Braun, P.G., and Sutton, J.C. - New approaches to managing botrytis grey mold in strawberries.

The objective of this project is to develop integrated practices for managing strawberry grey mold (*Botrytis cinerea*) which require less fungicide than is required in current practices for controlling the disease. A particular aim is to reduce or eliminate undesirable fungicide residues on the strawberry fruit at harvest while maintaining acceptable disease control. Our approach is to monitor distribution and intensity of disease and inoculum in the crop on a year-round basis. Special attention is being given to identifying cycles of disease increase in relation to season and weather factors. Specific management practices are being evaluated in terms of impact on grey mold epidemics.

Research was initiated in 1983 in existing strawberry beds at the Cambridge Research Station and at the Elora Research Station. In addition, new beds were established at the Arkell Research Station for use in future seasons. At Cambridge, effects of weather factors on sporulation and disease were examined. Weather was monitored in the crop canopy from May to November. Leaf wetness temperature, humidity, irradiance, wind speed and rain were monitored continuously using electrical-type sensors wired to a CR-21 datalogger. Relative humidity and temperature also were monitored with a hygrothermograph. Data analysis is in progress.

At Elora effects of cultural practices and fungicides timed to coincide with specific stages of epidemics are being studied in 4 m plots. Cultural practices include removal of crop debris at various times. Seven fungicide treatments were applied in the fall to strawberries in which crop debris was removed or not removed. Success of these treatments will be measured in the spring of 1984. Sporulation of Botrytis on leaf laminae, leaf petioles, fruits, etc., was monitored in check plots through the spring and summer. A possible means for biological control of grey mold was encountered.

B) Northover, J., and Biggs, A.R. - *Application of epidemiology to reducing fungicide requirements for controlling brown rot on stone fruits.*

Monilinia fructicola caused appreciable infection of blossoms of sweet cherries and peaches following a cool wet period during late bloom in May 1983. The infection of cherry blossoms was associated with improper seed set, as occurred also in 1982, and on peaches the blossom infections were more serious than usual and advanced into the one year old wood forming sporulating lesions.

The usually uncommon perfect stage, *Sclerotinia fructicola,* was found in a deliberately non-cultivated research orchard, and 30 mono-ascosporic cultures were made from five apothecia.

As an initial enquiry into the adequacy of fungicide recommendations for the protection of stone fruits against *M. fructicola,* fruit samples infected by brown rot were collected from 11 peach, 1 plum and 2 cherry orchards. Benomyl-resistant *M. fructicola* predominated in samples from 12 of these 14 locations, representing a substantial increase over the 2 resistant locations identified in 1982. This indicated the possibility of the widespread distribution of benzimidazole resistant brown rot in Niagara.

In laboratory studies, benomyl-resistant *M. fructicola* cultured on potato dextrose agar was just as aggressive to non-wounded cherry fruits as inoculum reared on sterilized peach halves. Controlled inoculation studies showed that the rapid spread of benomyl-resistant *M. fructicola* within an orchard could be prevented by a high degree of control of benomyl-sensitive (wild type) inoculum, achieved by the thorough use of full recommended rates of effective fungicides.

24. Tolman, J.H., and McLeod, D.G.R. - *Losses in production of processing tomatoes, cabbage (and onions) due to insects, diseases and weeds.*

In order to estimate potential yield losses by commercial growers of tomatoes and cabbages, separate trials were set up at two locations in the London area. For both crops, the six treatments (IFH, IFHoe, FH, IF, IH, O) were replicated four times in a randomized complete block design. In addition, potential yield losses in onions were measured for a third year.

Tomatoes

Heinz 318 tomatoes were transplanted into a sandy clay loam at the Fanshawe Field Station on June 10. Problem insect infestations did not develop and no insecticides were applied; significant tarnished plant bug damage to green fruit was, however, observed during the final picking on Oct. 3. Although weed stands were somewhat uneven, substantial populations of old witchgrass, pigweed and lambsquarters developed on herbicide-free plots. Weed populations were initially very well controlled by incorporation of a tank mixture of metribuzin + trifluralin at a cost of \$73.85/ha. Manual weeding (\$3.50/h) throughout the summer was costed at \$761.85/ha in herbicide-free plots and \$330.75/ha in herbicide treated plots. As a result of generally hot, dry weather significant disease did not develop until August 12 when early blight was first observed in fungicide-free plots. Defoliation was general in these plots by August 31.

Both early blight and anthracnose were observed on the fruit of non-treated plots by September 10, significantly decreasing yields at that time. Tomatoes were hand picked and graded on August 24, 31, September 9, 19, and October 3. Final results were as follows:

SOURCE OF LOSS	PROGRAM APPLIED	AVERAGE MARKETABLE YIELD (tonnes/ha)	[i]% YIELD LOSS	VALUE PER HECTARE ($123.04/t)	[i]LOSS PER HECTARE ($)
-	[ii]IFH	36.09	-	4440.51	-
-	IFHoe	40.31	+11.70	4959.74	+519.20
Insects	FH	insects not a problem; no insecticides applied			
Weeds	IF	12.00	*66.75	1476.48	2964.03
Diseases	IH	25.00	*30.73	3076.00	1364.51
[iii] In, W, D	0	6.64	*81.59	816.99	3623.52

* $p<0.05$
i - loss relative to complete IFH program
ii - I-insecticide; F-fungicide; H-herbicide; Hoe-manual weeding
iii - In-insects; W-weeds; D-diseases

Cabbage

Rio Verde cabbage were transplanted into a sandy loam near Hyde Park on June 8. Although diamondback moth, cabbage worm and cabbage loopers were all recorded in the plots, populations did not reach truly damaging levels; the extra yield recorded in insecticide-treated plots did not compensate for the cost of insecticide application. Although somewhat uneven, dense stands of pigweed and lambsquarters did develop; lesser populations of ragweed and several annual grasses were also recorded. Post transplant application of chlorthal dimethyl + metolachlor did not provide effective control of the high weed population resulting in only a 25% saving in the time required to maintain plots weed-free. Diseases were not a serious problem. Mature heads were harvested Aug. 30; all remaining cabbages were cut and graded Sept. 13. Results were as follows:

SOURCE OF LOSS	PROGRAM APPLIED	AVERAGE MARKETABLE YIELD (tonnes/ha)	[i]% YIELD LOSS	VALUE PER HECTARE ($55.27/t)	LOSS PER HECTARE ($)
-	[ii]IFH	42.13	-	2328.53	-
-	IFHoe	39.87	5.38	2203.61	124.92
Insects	FH	36.58	13.18	2021.78	306.75
Weeds	IF	11.09	*73.68	612.94	1715.59
Diseases	IH	diseases not a problem; no fungicides applied			
[iii] In, W, D	0	6.00	*85.76	331.62	1996.91

* $p<0.05$
i - loss relative to complete IFH program
ii - I-insecticide; F-fungicide; H-herbicide; Hoe-manual weeding
iii - In-insects; W-weeds; D-diseases

Onions

Rocket onions were planted in organic soil on the Thedford-Grand Bend Marsh on May 11. Onion maggot adults were first trapped May 16, but did not reach peak levels until the week of June 27; three generations were completed by the end of September. Thrip damage was recorded in insecticide-free plots by July 29 and had become quite heavy by Aug. 12; by Sept. 6 thrip damage was very severe with all leaves whitened by feeding and some older leaves actually dying. Dense stands of smartweed, purselane, lambsquarters, barnyard grass and crabgrass virtually carpeted herbicide-free plots by July 1, ultimately completely smothering the onion crop. The hot, dry weather did not favour development of Botrytis; first lesions were observed July 8 but lesion numbers remained fairly low throughout the season with significant leaf death developing only in the first week of September. Onions were pulled Sept. 14, harvested Sept. 22 and subsequently cleaned and graded. Results were as follows:

SOURCE OF LOSS	PROGRAM APPLIED	AVERAGE MARKETABLE YIELD (tonnes/ha)		*i* % YIELD LOSS	*ii* VALUE PER HECTARE	*i* LOSS PER HECTARE ($)
		#1 Sm.	#1 Reg.			
-	*iii* IFH	6.05	26.25	-	6463.05	-
Insects	FH	5.28	18.53	*26.43	4628.91	1834.14
Weeds	IF	0.00	0.00	*100.00	0.00	6463.05
Diseases	IH	7.73	19.55	*15.61	5026.23	1436.82
iv In, W, D	0	0.00	0.00	*100.00	0.00	6463.05

* $p<0.05$
i - total loss relative to complete program
ii - #1 Small - $66.00/t; #1 Regular - $231.00/t
iii - I-insecticide; F-fungicide; H-herbicide
iv - In-insects; W-weeds; D-diseases

If the results of the 3-year study are averaged, uncontrolled insects, weeds and diseases caused onion losses of 37.4%, 100.0% and 26.2%, respectively.

Results in 1983 emphasized the potential of uncontrolled weeds to depress yields of onions, tomatoes and cabbage. In the case of tomatoes and cabbage, mechanical weed control may be feasible; chemical weed control is essential in commercial onions. Whatever the method, weeds must be controlled if profitable vegetable production is to be maintained.

25. Tolman, J.H., and Tomlin, A.D. - *Feasibility of using parasites and predators in a program of integrated control of the onion maggot.*

As a result of continuing refinement and modification, the rearing method for the staphylinid beetle, *Aleochara bilineata (A.b.)* has progressed to the point where 6-7 person hours are producing 14,000 *A.b.* each week. Approximately 75% are reared under diapausing conditions and are being stored, for future release, as first instar larvae within the host puparium. The remainder are utilized for studies of biology and toxicology or for maintenance of the stock culture.

Laboratory studies showed longest survival and greatest egg production by *A.b.* at 15°C. In contrast to *Aphaereta pallipes*, which proved an effective parasite over only a relatively restricted temperature range, *A.b.* successfully parasitized 90% of presented *Delia antiqua* pupae at temperatures ranging from 15°C - 30°C. First instar *A.b.* larvae were able to move through organic soil at least 28 cm horizontally or 15 cm vertically to locate and successfully parasitize host pupae. Determination of the developmental thresholds of the various life stages of *A.b.* is continuing.

Twelve insecticides, five herbicides and three fungicides were tested at commercial formulations for residual toxicity to *A.b.* at the highest recommended rate of application. No herbicide or fungicide tested proved toxic to the beetles. The pyrethroids Ambush, Ripcord, Belmark, and Mavrik all appeared quite safe to *A.b.* not directly sprayed by insecticide; Decis was moderately toxic. Of the currently recommended insecticides, Dibrom and malathion proved non toxic to *A.b.* at suggested rates; diazinon was moderately toxic while parathion and Lorsban proved most toxic. The relative residual toxicity of several insecticides was tested on organic soil and Plainfield sand; all proved more toxic on Plainfield sand.

Microplots (0.5 x 1.0 m) set up on Barletta pickling onions growing in organic soil at the Fanshawe Field Station were infested with 250 eggs of *Delia antiqua*/m row and then covered to prevent infestation by native *D. antiqua* or predator/parasites. Onions were counted, varying numbers of *A.b.* introduced and onions counted again after four weeks to determine whether *A.b.* were able to reduce maggot damage. The first attempt failed due to dessication of *D. antiqua* eggs during extremely hot weather. In a second experiment in September, a population of 24 *A.b.*/m^2 reduced damage by 21.4%; increasing the population to 96 *A.b.*/m^2 onion damage by 47.6%.

At Thedford in 1983, adult flight activity of *A.b.* began between May 6 and 13. From laboratory studies it is known that *A.b.* diapauses as a first instar larva within *Delia* sp. puparia; these facts suggest that, in the field, *A.b.* overwinters as a first instar larva, completes larval development in the early spring and emerges as an adult in late April and early May. From May to mid-October (when adult flight activity ceases), *A.b.* completes a life cycle every 27-30 days (from laboratory studies) and adult activity is nearly constant throughout this period.

Analysis of Masner traps stationed at different heights revealed that *A.b.* flight is mainly confined to levels below 0.46 m. Catches in traps above this height were 17% of those below this height.

Pitfall traps were not nearly as efficient in trapping *A.b.* adults as Masner traps. Recapture levels of marked-released *A.b.* were so low in 1983 that estimates of their population levels lack confidence.

Three blocks, each measuring 45 x 12 m (7 beds), were set up in a commercial onion field on the Thedford-Grand Bend Marsh. Chlorfenvinphos 5G was applied as a seed furrow treatment; no other insecticides were applied to any block at any time during the summer. Beginning May 16 and continuing weekly for 18 weeks, 1000 *A.b.* adults were released on the first block. A total of five releases of 1000 *A.b.* at four-week intervals were made on the third block. The centre block served as a control. Two "micromountains" (0.25 m^2 tubs of sliced onions seeded with *D. antiqua* eggs) were established biweekly in each block. Five-six days after pupation of *D. antiqua*, "micromountains" were returned to the laboratory, pupae collected and examined for parasitism. Eight sets of "micromountains" were thus processed. In the weekly release block, mean parasitism by *A.b.* was 23.8%, significantly higher than the 14.5% rate of parasitism in the control block. *A.b.* parasitism averaged 13.2% in the block where beetles were released every four weeks.

Random onion damage counts taken just before harvest both in the experimental blocks and the adjacent grower field yielded the following results:

Soil Insecticide	*Aleochara bilineata*	Foliar Insecticide	% Onion Damage
-	-	-	12.8 ± 2.0 b*
+	-	-	3.6 ± 0.8 c
-	weekly	-	18.4 ± 1.6 a
+	weekly	-	6.2 ± 1.6 c
-	monthly	-	6.0 ± 1.4 c
+	monthly	-	2.6 ± 0.7 c
+	-	+	5.4 ± 1.5 c

* $p<0.05$ (DMRT)

Second generation onion maggot damage in the commercial field averaged 5.4%, not significantly different from damage recorded in plots with regular *A.b.* release or even the control plot where no *A.b.* were released. We suspect that the very hot, dry weather experienced last summer had at least two effects:

i - prolonged effectiveness of the seed furrow treatment
ii - reduced life span and effectiveness of released *A.b.*

At any rate, onion damage on the integrated block was no worse than damage recorded in the commercial field.

RESEARCH PROPOSALS FUNDED IN 1982/83 AND COMPLETED IN 1983/84

26. Tolman, J.H., Chapman, R.A., and Tomlin, A.D. - *Feasibility of protecting radish, rutabaga and onion from root maggot damage by insecticide seed treatment.*

After laboratory germination tests showed aldrin, isofenphos, chlorfenvinphos, chlorpyrifos, diflubenzuron, BAY SIR 8514, permethrin, and cypermethrin to be relatively safe to onions, radish and summer turnips, field microplot trials were carried out during both 1982 and 1983. Field effectiveness of seed dressings has now been evaluated in the following experiments: dry yellowseed onions - 2 trials; pickling onions - 1 trial; bunching onions - 1 trial; summer turnips - 1 trial; radishes - 2 trials on Plainfield sand, 2 trials on clay loam, 2 trials on organic soil.

Although both the synthetic pyrethroids permethrin and cypermethrin and the growth regulators diflubenzuron and BAY SIR 8514 did reduce root maggot damage in most crops, the degree of control achieved was not satisfactory at the tested rates (10-30 g AI/kg seed). Similarly, the organophosphorus (OP) insecticides isofenphos, chlorfenvinphos and chlorpyrifos did not provide reliable control of root maggot damage at the lower tested rates of 10 and 15 g AI/kg seed. At the higher rates of 20 and 25 g AI/kg seed, however, all three OP's provided generally acceptable control of root maggot damage in all tested crops except summer turnips. Control was frequently equal or superior to that achieved with a furrow granular application of the recommended rate of chlorfenvinphos. No insecticide provided satisfactory season-long control of cabbage maggot damage in summer turnips using the tested rates or application methods.

Delayed emergence and slight stand thinning were observed in plots treated with the higher rates of chlorfenvinphos. Vegetables generally grew out of this initial phytotoxicity within a few weeks with no major effects observable at harvest time. No pronounced field phytotoxicity was observed in the presence of either chlorpyrifos or isofenphos.

All three OP's provided some initial protection of newly emerged summer turnip seedlings against attack by the crucifer flea beetle.

Harvest samples showed no detectable residues of any insecticide in dry yellowseed onions. Traces of isofenphos (0.021 ppm) and chlorpyrifos (0.046 ppm) were recorded in pickling onions; only isofenphos (0.0088 ppm) was detected in bunching onions. Residues of all three OP's were, however, recorded in radishes harvested 5 weeks after planting; chlorpyrifos residues were highest at 0.1 ppm.

APPENDIX IV: PUBLICATIONS AND THESES RELATING TO ONTARIO PESTICIDES ADVISORY COMMITTEE RESEARCH PROGRAMS, APRIL 1, 1983 - MARCH 31, 1984.

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